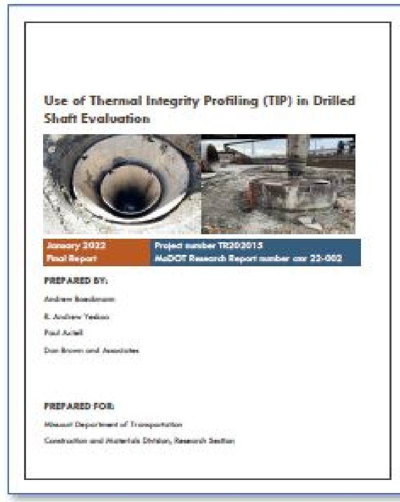
For more information contact: Jennifer Harper (573) 526-3636

Research Summary


Use of Thermal Integrity Profiling (TIP) in Drilled Shaft Evaluation

January 2022
Final Report

Project number TR202015
MoDOT Research Report number cmr 22-002

PREPARED BY:

Andrew Boeckmann

[illegible]

Paul Axtell

Dan Brown and Associates

PREPARED FOR:

Missouri Department of Transportation

Construction and Materials Division, Research Section

Use of TIP in Drilled Shaft Evaluation

Drilled shaft integrity tests are commonly performed to identify any imperfections that may have developed during drilled shaft construction. Among transportation agencies, including MoDOT, Crosshole Sonic Logging (CSL) is the most common integrity test method, but agencies have recently started implementing Thermal Integrity Profiling (TIP) as an alternative.

Whereas CSL uses geophysical measurements to identify potential imperfections, TIP uses temperature measurements during curing. Both tests have limitations, particularly with respect to the evaluation zones: CSL only evaluates the concrete within the drilled shaft reinforcing cage, and TIP temperatures are subject to rolloff at the top and bottom of the shaft.

The goal of this research was to support potential implementation of TIP methods for MoDOT projects. The primary objective was to evaluate the effectiveness, accuracy, and cost of using TIP and CSL to identify defects. An additional objective was to compare TIP with conventional thermal wire and TIP with fiber optic methods.

The research consisted of a literature review that included evaluation of other agencies' experience with TIP, evaluation of cost data, a laboratory study of fiber optic TIP, and a field evaluation. The field evaluation consisted of performing CSL and TIP on four production shafts, with two shafts at two bridge sites.

Several previous studies have been performed to evaluate the effect of imperfections on TIP results. A Wisconsin DOT study comparing TIP and CSL resulted in the conclusion that the tests are generally complimentary in terms of defect detectability, with TIP more effective for identifying weak concrete defects and defects outside the reinforcing cage and CSL more effective for identifying soft bottom conditions and defects within the reinforcing cage.

Much of the TIP analysis from the field study focused on the results at the bottom of the shafts, where soft bottom conditions were observed for one of the two shafts at each bridge site. Contrary to the results of previous studies, soft bottom conditions were potentially identifiable in the TIP records from this field study. The soft bottom conditions were most evident from evaluation of the temperature vs time records.

The researchers concluded both CSL and TIP should be allowable test methods, with the specific method for any given project selected on the basis of project-specific considerations. Additional recommendations included that TIP interpretation should include review of all construction records and review of temperature vs time for depths with potential imperfections.

Published cost data and cost data from the field component of this work suggest the cost of implementing TIP methods may be less than the cost of implementing CSL methods. The cost of TIP wire, generally $5/ft as of the date of this

report, is similar to the cost of steel tubes for CSL. However, TIP data is generally collected remotely via datalogging equipment that is simple to install and can generally be managed by personnel already on site.

Finally, the research showed that fiber optic TIP methods produce the same temperature results as conventional TIP methods. The fiber optic methods involve inexpensive cabling but relatively costly analysis equipment. Fiber optic methods also require collection by trained personnel, which limits the collection of a continuous time record.

> *"The researchers concluded both CSL and TIP should be allowable test methods, with the specific method for any given project selected on the basis of project-specific considerations."*

Figure 1: Concrete placement for a Ramp F shaft.

Project Information

PROJECT NAME: TR202015—Use of Thermal Integrity Profiling (TIP) in Drilled Shaft Evaluation

PROJECT START/END DATE: April 2020-December 2021

PROJECT COST: $150,000

LEAD CONTRACTOR: Dan Brown & Associates

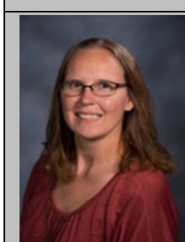
PRINCIPAL INVESTIGATOR: Andy Boeckmann

REPORT NAME: Use of Thermal Integrity Profiling (TIP) in Drilled Shaft Evaluation

REPORT NUMBER: cmr 22-002

REPORT DATE: January 2022

Project Manager



CONTACT INFORMATION:

Jennifer Harper
Research Director
Missouri Dept. of Transportation
1617 Missouri Blvd.
Jefferson City, MO 65109
(573) 526-3636
Jennifer.Harper@modot.mo.gov